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October 18, 2017

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: ViaSat, Inc., *Ex Parte* Submission, GN Docket No. 14-177; IB Docket Nos. 15-256 & 97-95; RM-11664; and WT Docket No. 10-112

Dear Ms. Dortch:

On October 2, 2017, ViaSat, Inc. submitted a paper entitled, "Fixed-Satellite Service Earth Station Receiver and 5G Coexistence." Enclosed is a revised version of this paper, which has been extended to include an analysis of a 1.8 meter earth station mounted on the ground.

Please contact the undersigned if you have any questions regarding this submission.

Respectfully submitted,

/s/

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Revised October 18, 2017

FIXED-SATELLITE SERVICE EARTH STATION RECEIVER AND 5G COEXISTENCE (INCLUDING GROUND MOUNT ANTENNAS)

1 EXECUTIVE SUMMARY

This analysis of a typical deployment scenario considers the case of small Fixed-Satellite Service (FSS) earth stations (ES) operating with downlink (space-to-Earth) reception in the 37.5-40 GHz band from geostationary-orbit (GSO) spacecraft. It shows that those FSS ES can be located in the same urban areas as a Fifth-Generation (5G) wireless network without the need for coordination.

The analysis, similar to the Roberson Report [1], utilizes standard methodologies, parameters, and metrics, and also uses published characteristics of the 5G IMT system [2]. This analysis also considers the case of a ground-mounted ES, in addition to that of a roof-mounted ES.

While the coexistence metric for FSS networks operating below 30 GHz has long been established as an increase in the thermal noise of the receiver of 6% commensurate with an I/N of -12.2 dB, the coexistence metric for FSS networks in the frequencies above 30 GHz is currently under consideration at the ITU. This analysis therefore considers a range of I/N values, namely -6, -10, and -12.2 dB.

The analysis considers a 1.8 meter earth station with the earth station antenna pointing in a fixed direction at a realistic elevation angle toward a GSO satellite, and uses a Monte Carlo simulation to place the earth station and the 5G cells (base station (BS) and associated user equipment (UE)) at random locations within a one kilometer square area. The simulation then develops statistics for earth station receiver I/N based on over one million random location samples that are then used to generate a cumulative distribution function (CDF) for the percent of locations where an I/N (-6, -10, or -12.2 dB) into the earth station receiver is exceeded.

The results demonstrate that the subject earth station can operate successfully inside a 5G deployment without the need for coordination because the earth station can operate in close proximity to the 5G network. The result is the same (i) in the case of a roof mounted 1.8 m antenna with 20 dB of additional attenuation from the roof line or parapet wall, and (ii) in the case of a ground mounted antenna in an enclosure, or with other screening, that provides 20 dB of additional attenuation.

2 TECHNICAL ANALYSIS

Introduction

The study investigates the effect on an FSS receiver of a 5G system composed of several base stations and user equipment. In the simulation, which is performed using Visualyse Pro software from Transfinite, the FSS receiver is immersed inside the 5G distribution. The location of the ES is varied randomly within a one kilometer square area and then a number of 5G BS and associated UE stations are randomly placed within the area. The process is repeated for a million iterations with a snapshot taken at each iteration and a CDF of I/N versus location generated.

2.2 Characteristics of 5G (IMT-2020)

The 5G system parameters and deployment scenarios to be used in the sharing and compatibility studies are found in the ITU document that is being used internationally to analyze frequency sharing/interference between IMT systems (i.e., 5G) and FSS networks in frequency bands 24.25 GHz to 86 GHz [3].

The 5G systems setup is outlined in section 8 of Recommendation ITU-R M.2101. In this analysis, the following 5G parameters and configurations, and other salient methodologies, are used:

1. One million snapshots are used to generate the CDFs;
2. e.i.r.p. densities are -35.6 dBm/Hz for BS and -50.9 dBm/Hz for UE;
3. Micro urban hotspot below the roofline scenario with BS height at 6 m and UE at 1.5 m. All BS and UE are outdoor. One square kilometer area includes six BS and three active UE per BS. The BS and UE are placed inside that area;
4. The location of BS and UE vary for each snapshot. The UE are distributed in the area defined by the BS azimuth coverage of 120° degrees and up to 100 m from the BS. The BS azimuth coverage direction is random for every snapshot;
5. 20% network loading activity factor reduces the total number of active BS and UE by 80%;
6. There are 30 BS per km^2 and three UE that can be associated with each BS;
7. TDD factors reduces the simultaneous transmissions of BS by 20% and the UE by 80%;
8. At each snapshot, the following parameters are randomized:
    i. Locations of BS and the UE associated with that BS;
    ii. BS and UE antenna elevation and azimuth angles within a given sector depending on the link using beamforming antennas according to Recommendation ITU-R M.2101;
    iii. The BS and UE that are active (based on TDD factor);
    iv. The UE transmit power control level based on the UE proximity to the BS;
9. BS do not use power control in the downlink;
10. Reference emission bandwidth is 60 MHz for BS and UE;
11. The propagation model for the 5G system is from Doc. 5-1/36. Micro urban scenario is used with parameters from Recommendation ITU-R P.1411 "Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz". The parameters for the non-line of sight path loss with the coefficients (from P.1411 Table 4) where α=5.06, β=-4.68, γ=2.02 and σ=9.33.

The results are presented as CDFs for:

1. BS antenna gain toward the UE;
2. Downlink carrier-to-noise C/N ratio.

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FIGURE 1

BS to UE antenna gain CDF

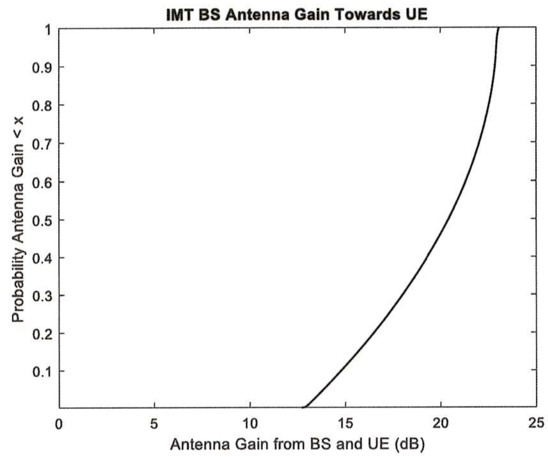
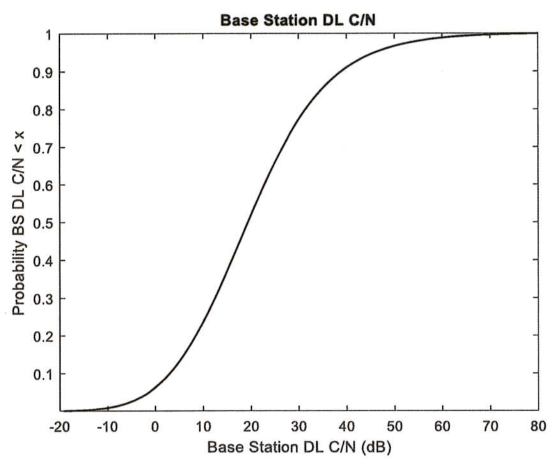


FIGURE 2

BS down link C/N



2.2 Characteristics of FSS systems

The FSS characteristics used in this analysis are shown in Table 1 below.

TABLE 1

FSS/BSS downlink parameters

Parameter	**Unit**	**1.8 m Diameter**
Frequency range	GHz	37.5-40
Noise bandwidth	MHz	50-500
Earth Station Antenna diameter	m	1.8
Peak receive antenna gain	dBi	55.4
Antenna receive gain pattern	–	Rec. ITU-R 465-6
System receive noise temperature	K	150
Minimum earth station elevation angle	°	35
Interference to Noise Ratio I/N	dB	-12.2, -10 and -6

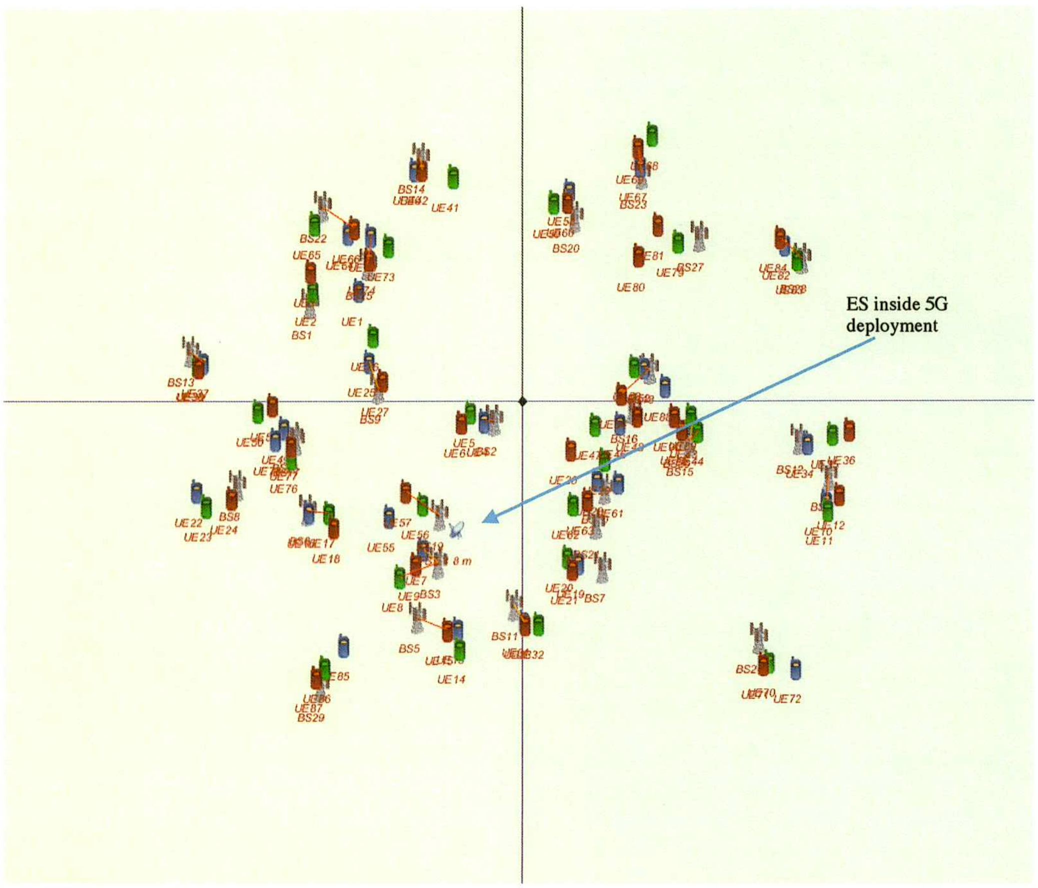
2.3 Analysis scenarios and assumptions

The 5G setup is as described above. The 5G stations and the FSS earth station are randomly placed at each snapshot as shown around a center point in the analysis area, which is one km^2. The snapshot in Figure 3 is taken from one of one million iterations. Note in Figure 3 the earth station icon is immersed inside the 5G distribution and surrounded by the icons for the various BS and UE stations.

In each iteration of the simulation, the orientation of the earth station and the 5G BS and UE stations will change. In some cases, the orientation of UE and BE stations will result in alignment with the main beam of the earth station and the BS antenna. In others, there will be an alignment with the UE beam, and so on. The Visualyse software's Monte Carlo process calculates and records the I/N into the ES receiver that results from that random placement of all the stations for that iteration.

FIGURE 3

Example snapshot of one million of the random placements of 5G BS and UE and the FSS station



The following assumptions are also used:

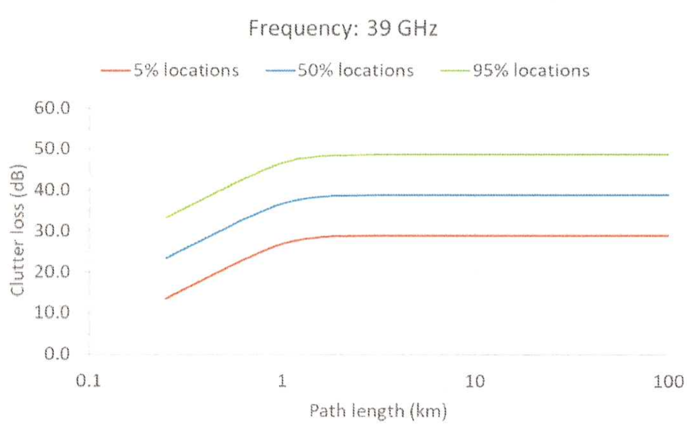
1. The 5G network scenario is as described above;
2. Clutter models used for the transmit link from 5G towards the FSS receiver are from Document ITU-R TG 5-1/38. Two models are used. The first is Recommendation ITU-R P.2001 "A general purpose wide-range terrestrial propagation model in the frequency

range 30 MHz to 50 GHz". The time percentages from 0 % to 100% are chosen randomly for each time sample. The other is Recommendation ITU-R P.2108 "Prediction of Clutter Loss" section 3.2. The clutter is applied at the 5G transmitter side as well as the FSS receiver side according to Recommendation ITU-R P.2108. The percent of locations for clutter is random between 0% and 100% for every sample[1];

3. The FSS center frequency is 39 GHz;
4. FSS antenna height is 12 meters or ground mounted;
5. For each BS, three UE are employed at center frequencies of 38.933 GHz, 39.0 GHz and 39.067 GHz;
6. Frequency dependent rejection (FDR) is accounted for;
7. Polarization loss is set to 3 dB;
8. The FSS coexistence criteria is under discussion within the ITU-R working parties. For this analysis -12.2 dB, -10 dB and -6 dB are considered. The percent of time exceedance is needed to determine compatibility;
9. FSS bandwidths are 50 MHz and 500 MHz;
10. The 5G emission mask in dBc and 60 MHz measurement bandwidth are shown below;
11. The FSS receiver selectivity are shown below. The selectivity filters have -80 dB per decade slope from the -3 dB point to -70 dB floor. A faster filter roll-off can provide better rejection;
12. The 12-meter-high roof mount FSS ES installation is used, with a roofline, parapet wall or other shielding providing an additional R.F. isolation of at least 20 dB to the 5G BS and UE configuration.
13. The ground mount FSS ES installation places the antenna mount at 2 m above ground and uses an enclosure similar to Figure 7 that provides an additional R.F. isolation of at least 20 dB to the 5G BS and UE stations.

FIGURE 4

Clutter loss



[1] Note these clutter models do not account for clutter closer than 250 m from the station.

FIGURE 5

5G emission masks

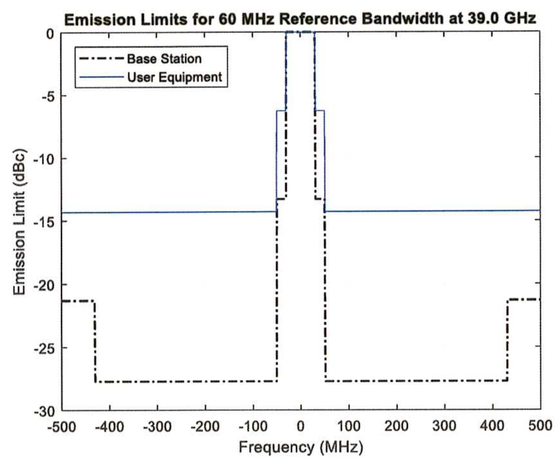


FIGURE 6

FSS receiver selectivity

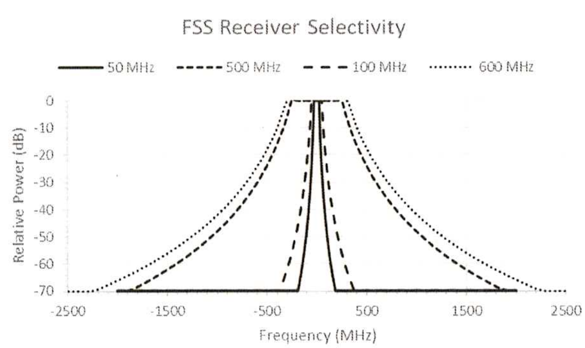


Figure 7

Fully Enclosed Ground Mount

3 Results

The results of the simulations for the three I/N values are shown below.

TABLE 2

5G and roof mounted 1.8 m FSS ES summary of results

FSS Bandwidth (MHz)	50	500
Locations where -12.2 dB is not exceeded (%)	99.69	99.99
Locations where -10 dB is not exceeded (%)	99.87	99.99
Locations where -6 dB is not exceeded (%)	99.98	100

Table 2 indicates that with a greater than 99.69% confidence level (roughly 3 sigma) that a roof mounted earth station of the type considered here, and with the minimum additional 20 dB of attenuation reasonably expected of a roof top installation, could be deployed within a 5G network and not experience more than -12.2 dB I/N.

The CDF plot in Figure 8 below shows the percentage of simulation iterations where the I/N was greater than a given value. The plot shows that for the vast majority of random deployments of stations, the expected level of I/N was vanishingly small.

TABLE 3

5G and ground mounted 1.8 m FSS ES summary of results

FSS Bandwidth (MHz)	50	500
Locations where -12.2 dB is not exceeded (%)	98.756	99.396
Locations where -10 dB is not exceeded (%)	99.134	99.590
Locations where -6 dB is not exceeded (%)	99.614	99.812

Table 3 indicates that with a greater than 99.4% confidence level (nearly 3 sigma) that a ground mounted earth station of the type considered here, operating with a 500 MHz wide carrier (such as that used by ViaSat), and with the minimum additional 20 dB of attenuation reasonably expected of a block wall enclosure, could be deployed within a 5G network and not experience more than -12.2 dB I/N. Based on ViaSat's previous testing,[2] it is actually more reasonable to expect 25 dB to 30 dB of attenuation from such a block wall enclosure. Factoring in such higher signal attenuation, for example, the 98.756% value becomes 99.5% with 25 dB of such attenuation, and it becomes 99.784% with 30 dB of such attenuation.

The CDF plot in Figure 9 below shows the percentage of simulation iterations where the I/N was greater than a given value. The plot shows that for the vast majority of random deployments of stations, the expected level of I/N is vanishingly small.

2 See reference [4].

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FIGURE 8

5G System and 1.8 m Diameter FSS ES at height of 12 m CDFs

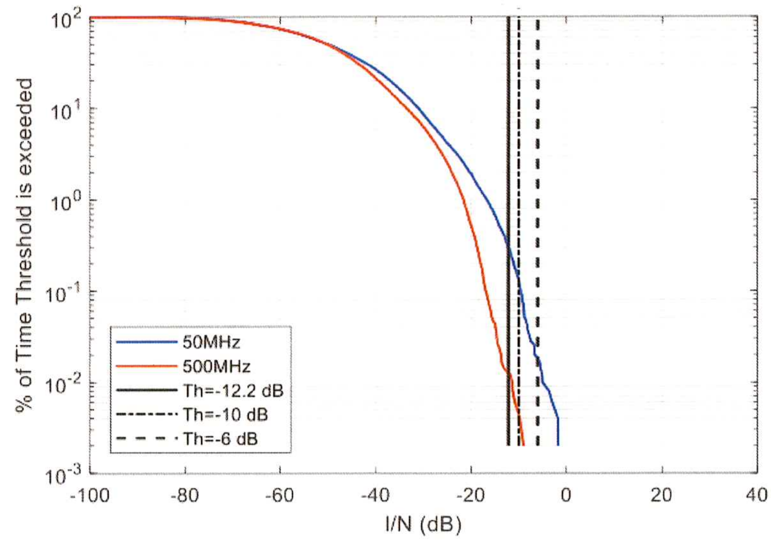
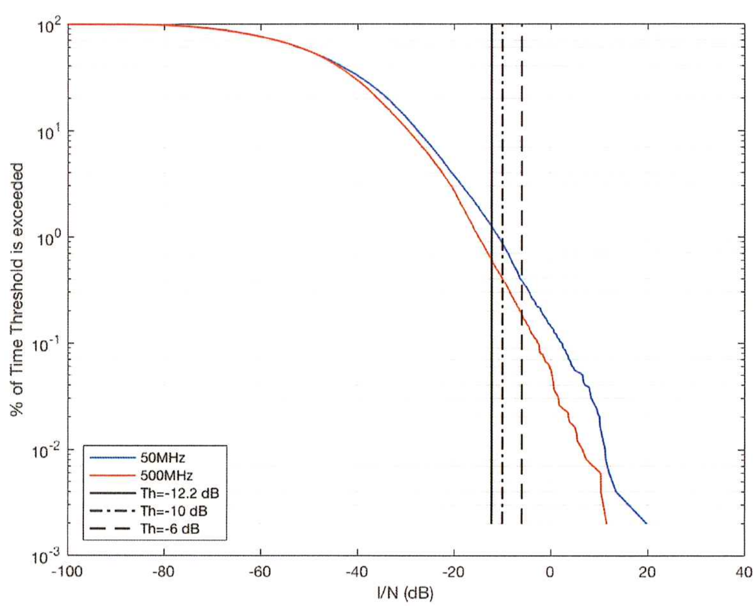


Figure 9

5G System and 1.8 m Diameter Ground Mounted FSS ES CDFs



4 Conclusion

The analysis above shows that when a roof mounted or ground mounted 1.8 m diameter FSS is placed inside a 5G distribution in an urban clutter zone, and the roof line, a parapet wall, block wall enclosure, or other shielding provides at least an additional 20 dB of attenuation over normally expected clutter losses, the potential impact on the FSS receiver is negligible and coordination of stations is not required.

This result is consistent with measurements taken of a roof mount transmit earth station at 28 GHz which demonstrated the positive impact of locating the earth station in such a typical roof mount configuration [4], where in most cases the attenuation was greater than 20 dB, and more than 40 dB or beyond the measurement capability of the test equipment in many cases, and with the Roberson report which considered the uplink (Earth-to-space) scenario in an urban setting and that also concluded that coexistence is feasible without coordination because the transmit earth station can operate in close proximity to the 5G network.

5 References

[1] Roberson Report, attached to ViaSat, Inc. Ex Parte Submission in GN Docket No. 14-177, September 25 2017

[2] ITU WP5D Liaison to TG 5/1

[3] Doc. ITU-R TG 5-1/36, Attachment 2

[4] Carlsbad Report, attached to ViaSat, Inc. Ex Parte Submission in GN Docket No. 14-177, April 20, 2017

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October 18, 2017